

# Evacuation Time Estimates

**IMUG Meeting**

**June 10, 2019**

**Sergio Gonzalez**

**U.S. Nuclear Regulatory Commission**

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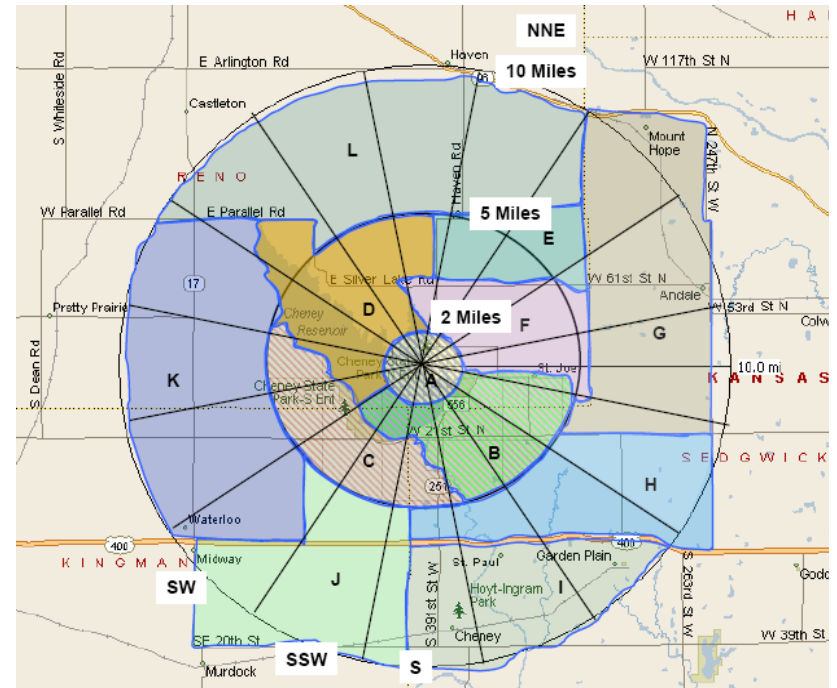
# ETE Study

- Objective
  - Conduct an applied research study of the modeling and simulation of ETEs and produce a technical basis for revision of NUREG/CR-7002 “Criteria for Development of Evacuation Time Estimate Studies” in support of the 2020 update of ETEs ([10 CFR Part 50 Appendix E](#))
- Who performed the study?
  - Transportation and evacuation experts at Louisiana State University and Embry-Riddle Aeronautical University (ERAU)
- NRC POC
  - NSIR: Todd Smith
  - RES: Sergio Gonzalez/ Jonathan Barr

# What is an Evacuation Time Estimate (ETE)?

Analyses of the time required to evacuate various sectors and distances within the plume exposure pathway emergency planning zone (EPZ).

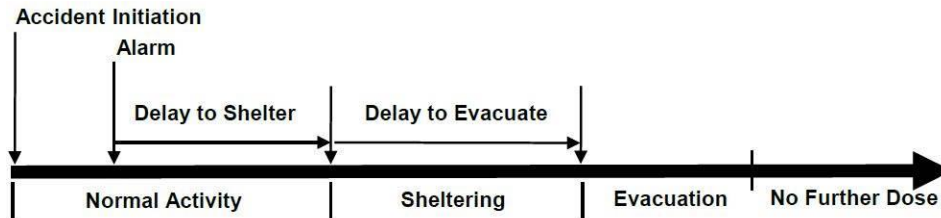
- Used to inform protective action recommendations in the event of an emergency
- Required by 10 CFR 50 App. E and 50.47(b)(10)
- NRC's current guidance in NUREG/CR-7002



# How is EP modeled in MACCS?

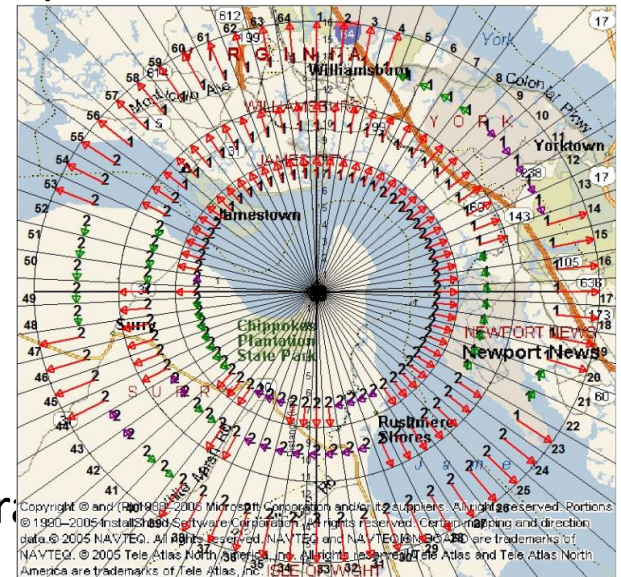
## Emergency Phase Modeling

- Protective actions (evacuation, sheltering, relocation, KI)
- Cohort timeline (general population, schools, special facilities, evacuation tail, shadow evacuees, non-evacuees)
- Travel direction and speed



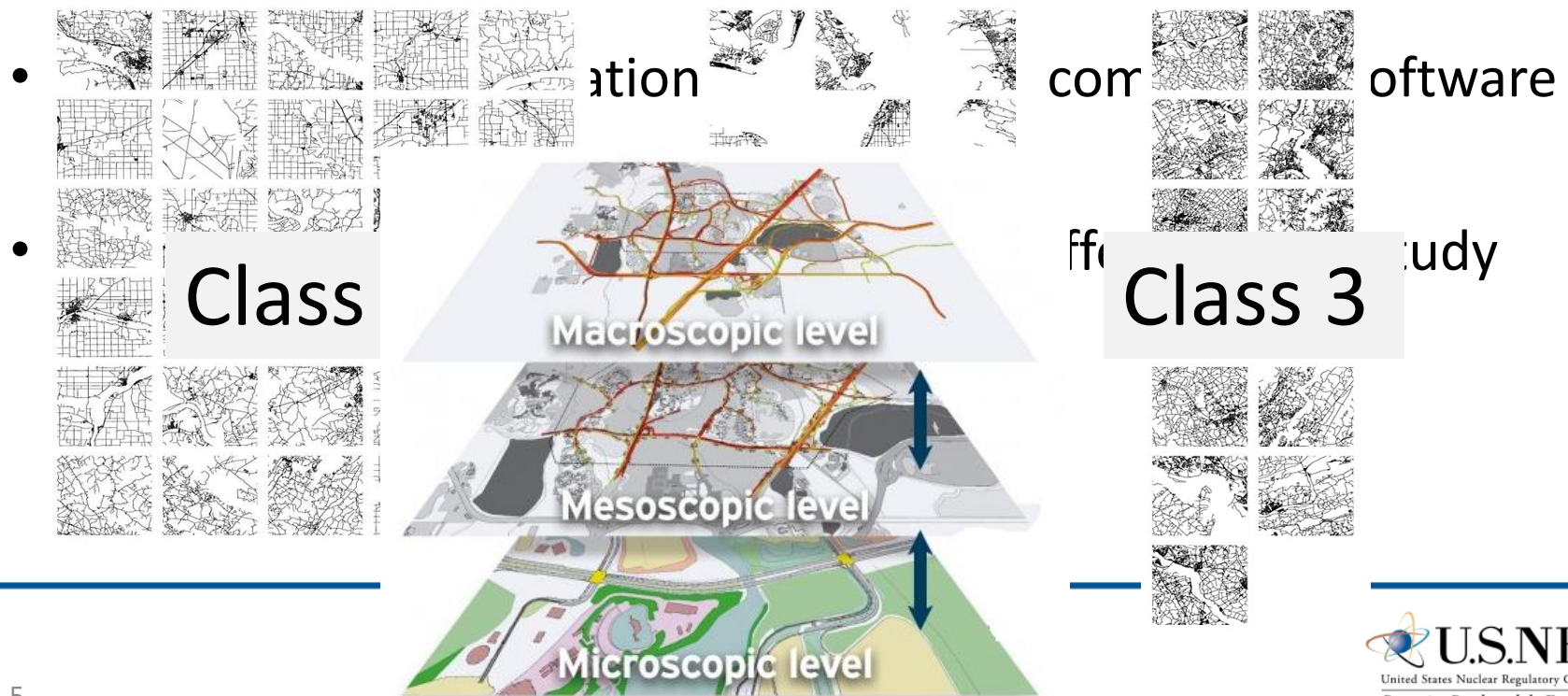
## How parameters are informed

- Evacuation time estimate (ETE) studies and travel time data
- MACCS modeling best practices
- Discussions with state and local authorities



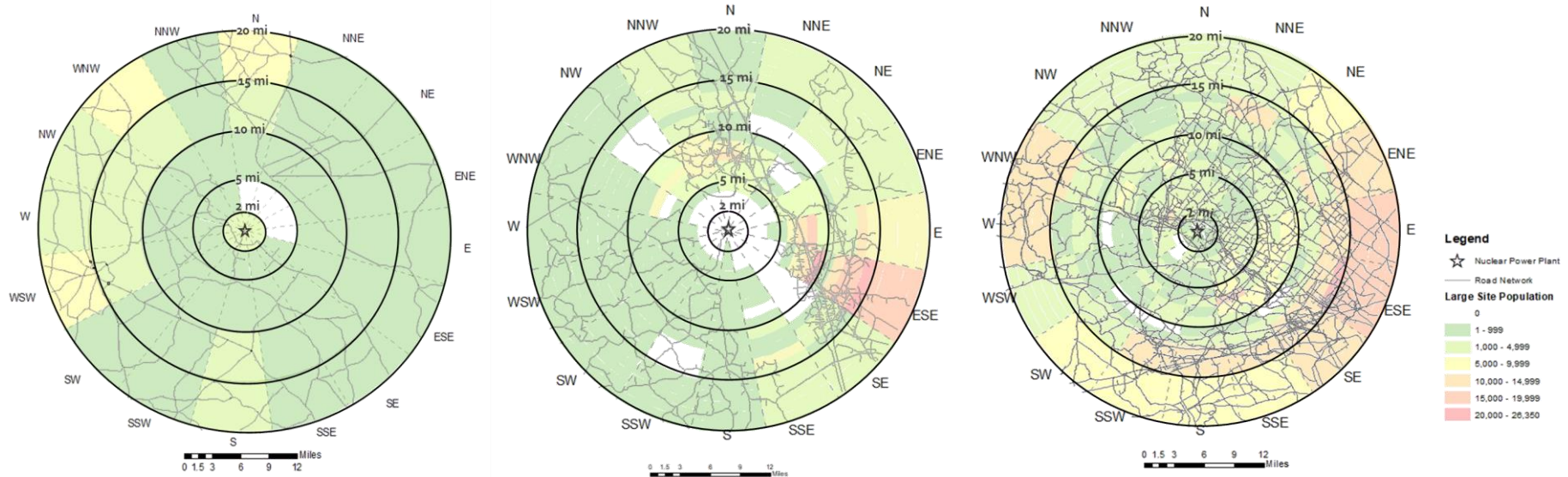
# ETE Study: Methodology

- Model 3 representative sites (small, medium, large population and representative roadway networks)



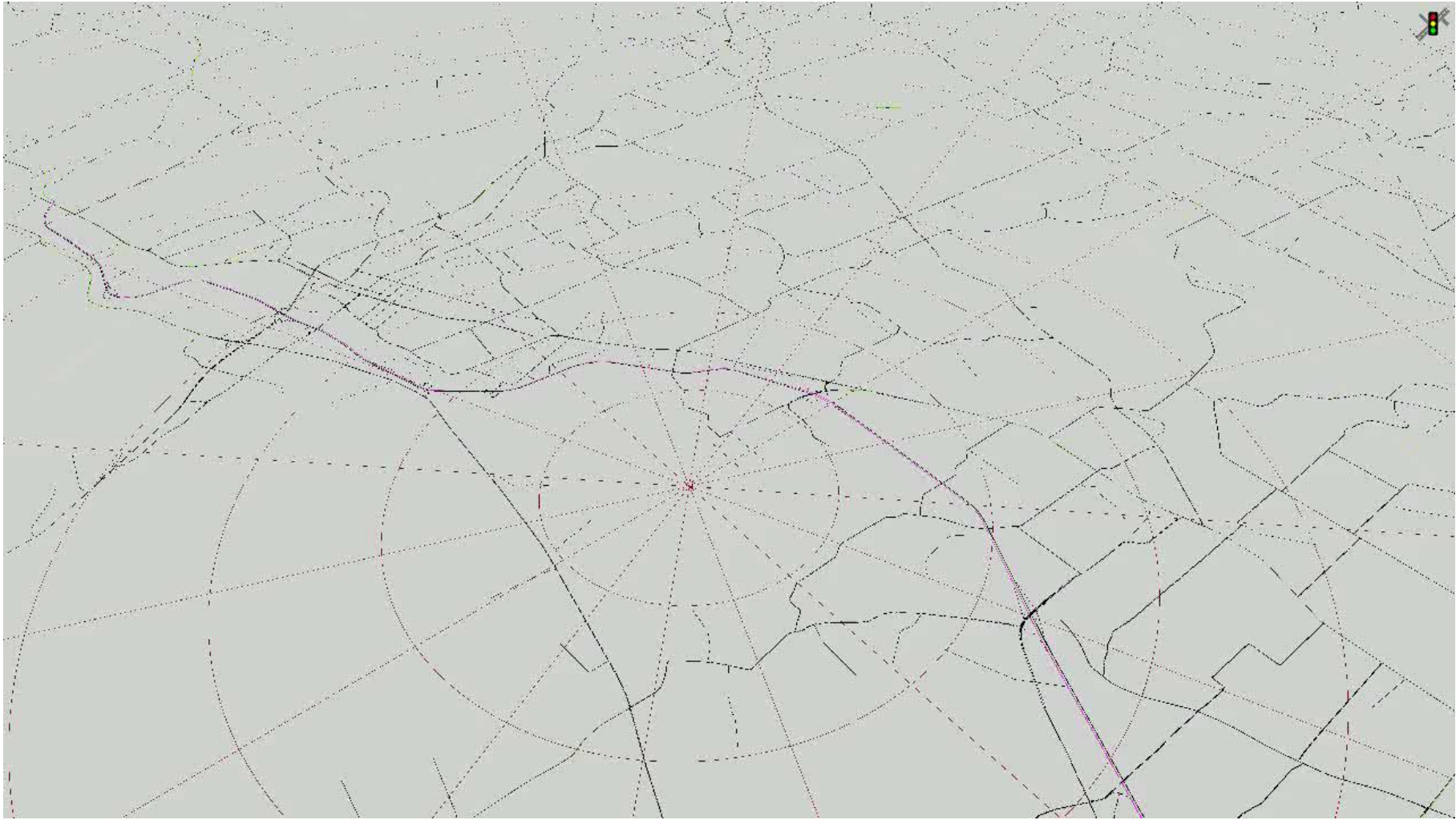


# ETE Study: Models



Model Comparison	EPZ POPULATION	MODEL EPZ POPULATION		MODEL STATS		
	0-10 MILE	0-10 MILE	20% SHADOW	INTER-SECTIONS	MILES OF ROAD	LINKS/CONNECTORS
SMALL	0 – 50,000	7500	3000	174	1196	376/863
MEDIUM	50,000 – 200,000	200,000	30,000	449	3313	2645/3846
LARGE	> 200,000	325,000	60,000	974	3712	10605/14719

# Video of Microscopic Traffic Simulation Model



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# ETE Study: Tasks

## **Task 1: Impact of Shadow Evacuation**

- Sensitivity of shadow participation rate on clearance times

## **Task 2: Distance of Evacuation Travel**

- Sensitivity of model extent on clearance times
- Assess travel times outside of EPZ

## **Task 3: Manual Traffic Control (MTC)**

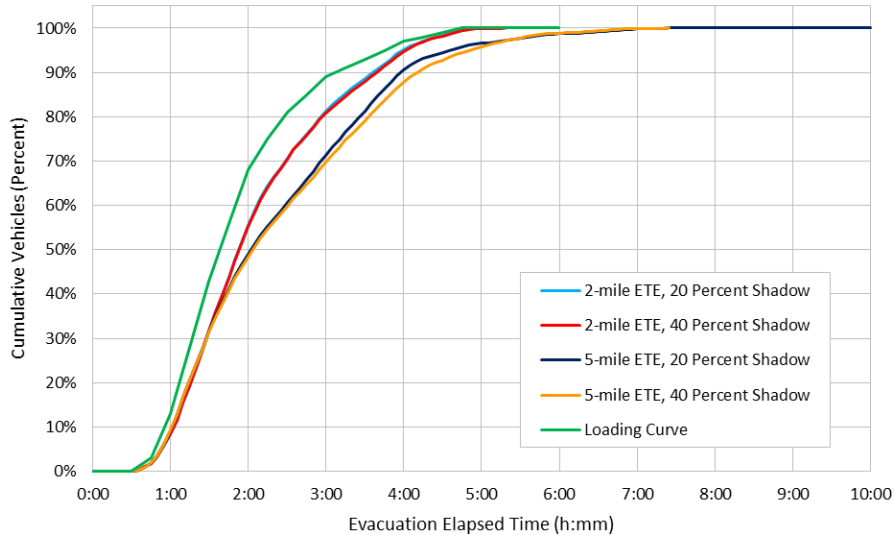
- Compare simulated MTC to signalized intersection control

## **Task 4: Parameters of Importance**

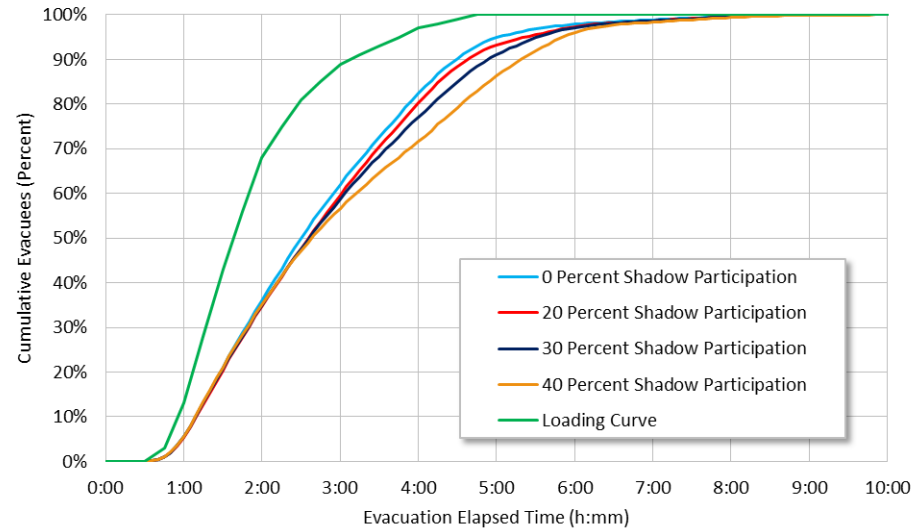
- Sensitivity analysis to determine importance of input and process variables to clearance times



# Shadow Evacuation

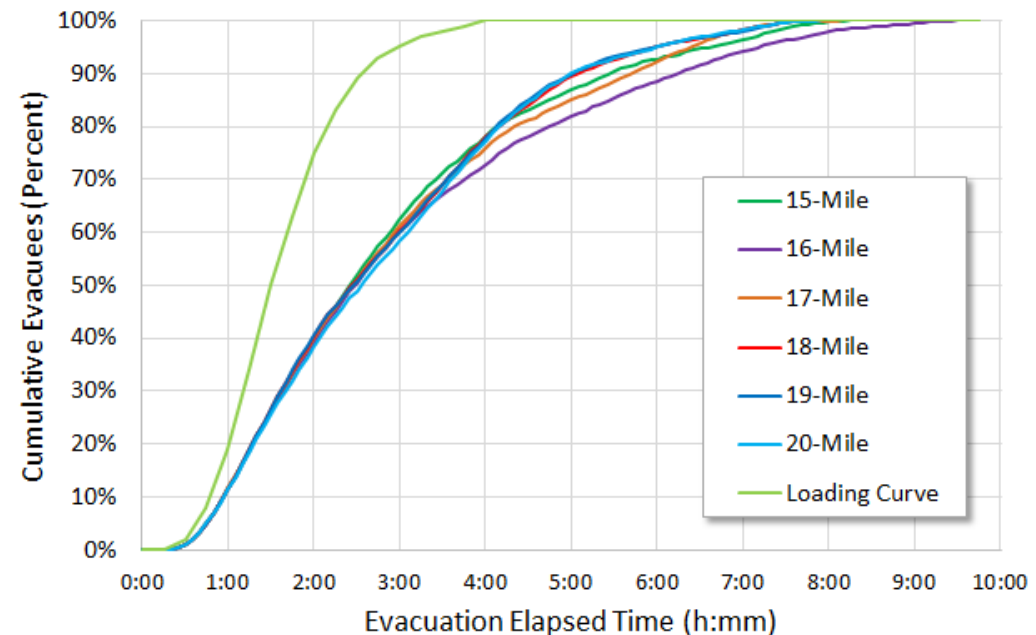
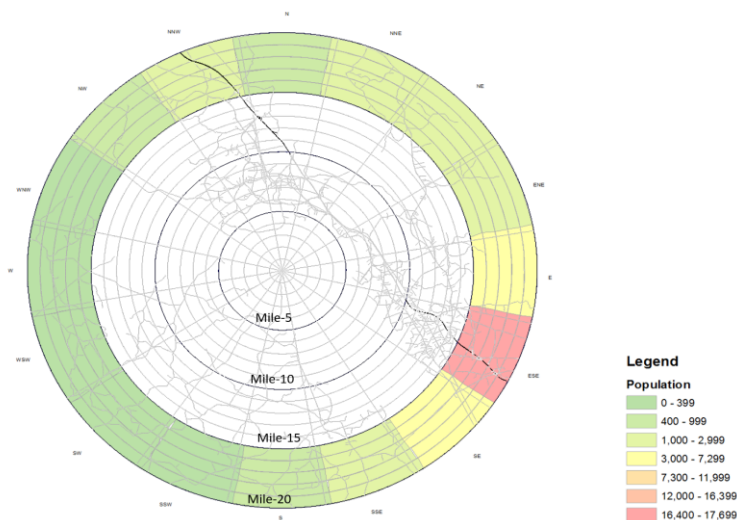


- Minimal to no impact on evacuees close-in to NPP
- Not a controlling factor in evacuations



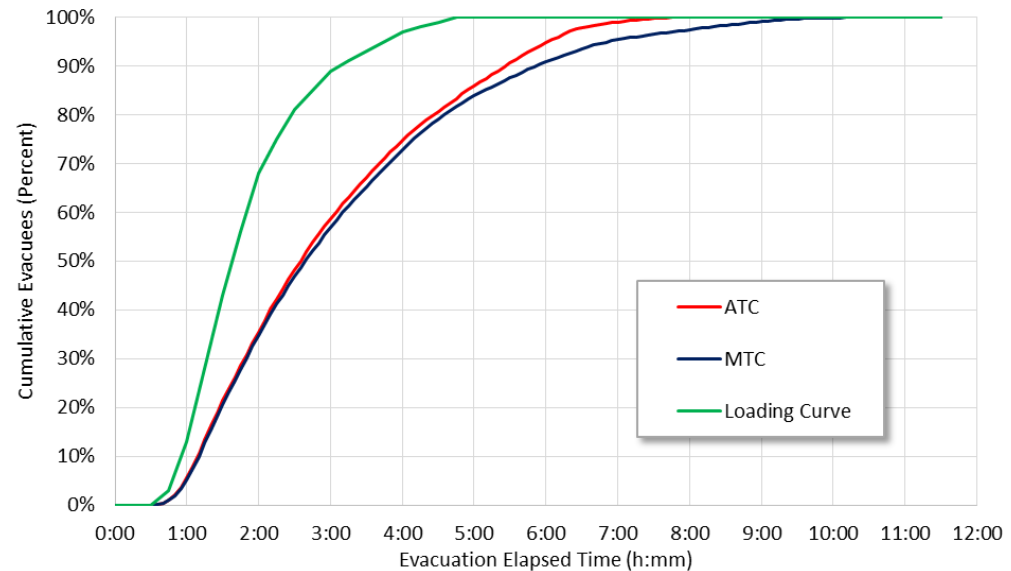
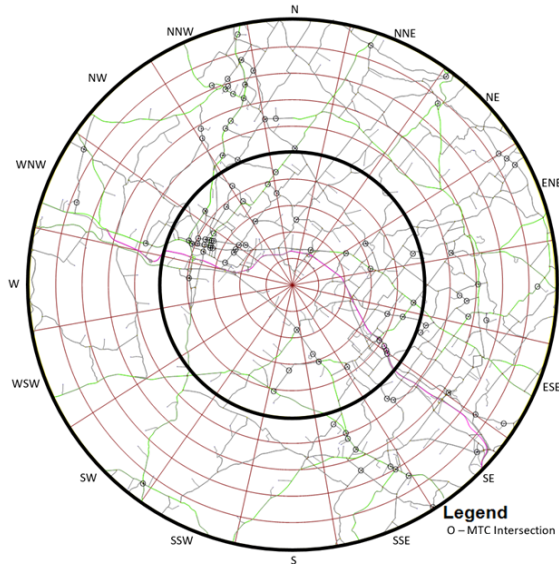
- Shadow affects only 20-30% of evacuees late in the evacuation
- Only significant at high participation rates (40%) which are unlikely

# Model Extent



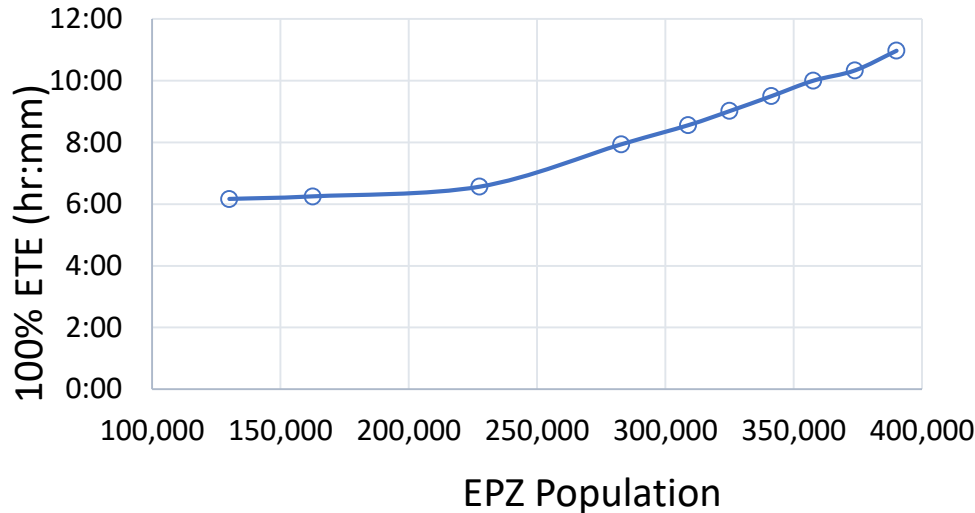
- Actual route varies based on available paths and their cost
- Bottlenecks, and/or higher population areas have an impact on ETE

# Manual Traffic Control



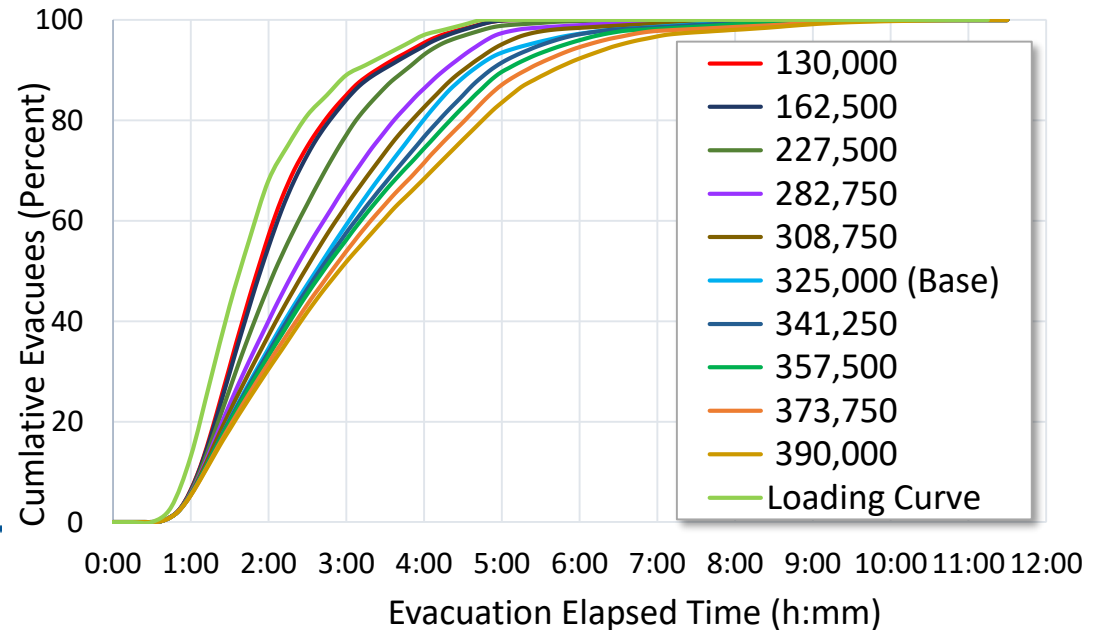
- Manual Traffic Control (MTC) is useful in limited situations, such as loading vehicles onto roads from large parking lots
- MTC has no advantages over Automated Traffic Control (ATC) for improving evacuation efficiency
- MTC resources could be employed elsewhere

# Population Results

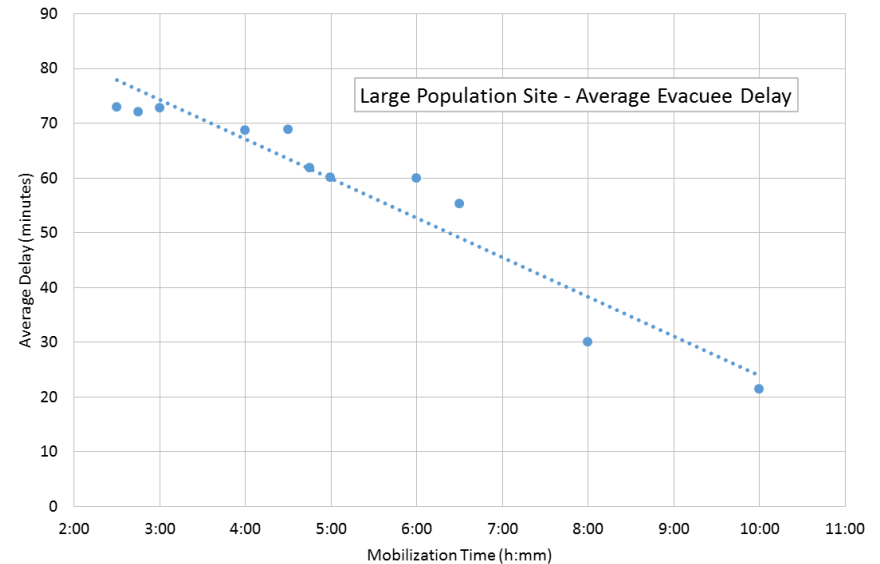
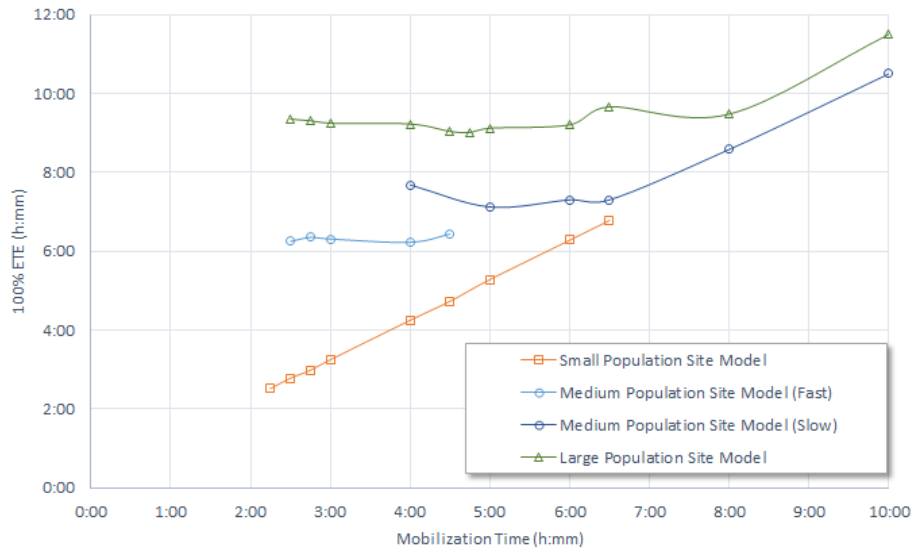


- Population threshold indicates congested and non-congested networks

- Relationship between demand and capacity is important
- ETE is sensitive when model is congested



# Mobilization Time



- Mobilization time is dominant component of ETE in non-congested sites
- For congested sites, shorter mobilization times create longer evacuee delays



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# Key Insights/Conclusions

- Shadow population not a significant impediment to evacuation
- Major population generators and bottlenecks after the typical 15 mile models can impact ETE
- Manual traffic control has limited utility
- Important Demand Parameters
  - Population
  - Mobilization time
- Important Capacity (supply) parameters
  - Weather
  - Roadway impacts

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# Summary

- Models provide a better understanding of parameters of interest
  - NRC models are most extensive microsimulation models ever developed for ETE
  - Offer unique insights into evacuation dynamics
- Study provides a technical basis for revision of current ETE guidance in NUREG/CR-7002
- Study will improve our ability to model EP using MACCS for various regulatory applications
- Results not limited to NPPs. Study enhances understanding of evacuation dynamics and traffic simulation modeling of all-hazards.

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# Questions?